The Driver - Vehicle - Environment Model

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Summary

- Overview on Joint Driver Vehicle Environment models (DVE)
- Global and Embedded DVE
- Review of existing Joint DVE
- Selection of the most suitable for AIDE requirements
- AIDE Global DVE model (G_DVE)
- AIDE Embedded DVE model (E_DVE)
  - Driver model
  - Vehicle model
  - Environment model
- Computational numeric simulation of the DVE

Joint Driver Vehicle Environment (DVE) model: overview

The model is based on the concept of a **"joint" cognitive system:**

- The dynamic interactions between Driver, Vehicle and Environment are represented in a harmonized and integrated manner
- The interactions between Driver-Vehicle-Environment are presented in a simplified way to enable fast computing
- Essential correlations between the independent variables
- Driver behavior prediction in dynamic and rapidly changing conditions

Global and Embedded DVE

- **G_DVE (Global DVE):** will support designers to predict the behaviour of the joint DVE system. It represents the theoretical generalization of the DVE model.
- **E_DVE (Embedded DVE)**: it will be part of the computerized numerical simulation of the DVE (the SSDrive system).

Review of existing Joint Driver Vehicle Environment models

- Selection from the literature of the most suitable candidate Joint DVE model from a list of 21.
- **Model requirements for AIDE's Global and Embedded DVE**:
  - the model should be able to predict driver performance;
  - the model should be able to account for multiple, simultaneous activities;
  - the model should be recursive and capable of describing one or more of the interactions between driver, vehicle and environment, or between all three.

DVE model candidate list

Selected Joint models for Global and Embedded DVE

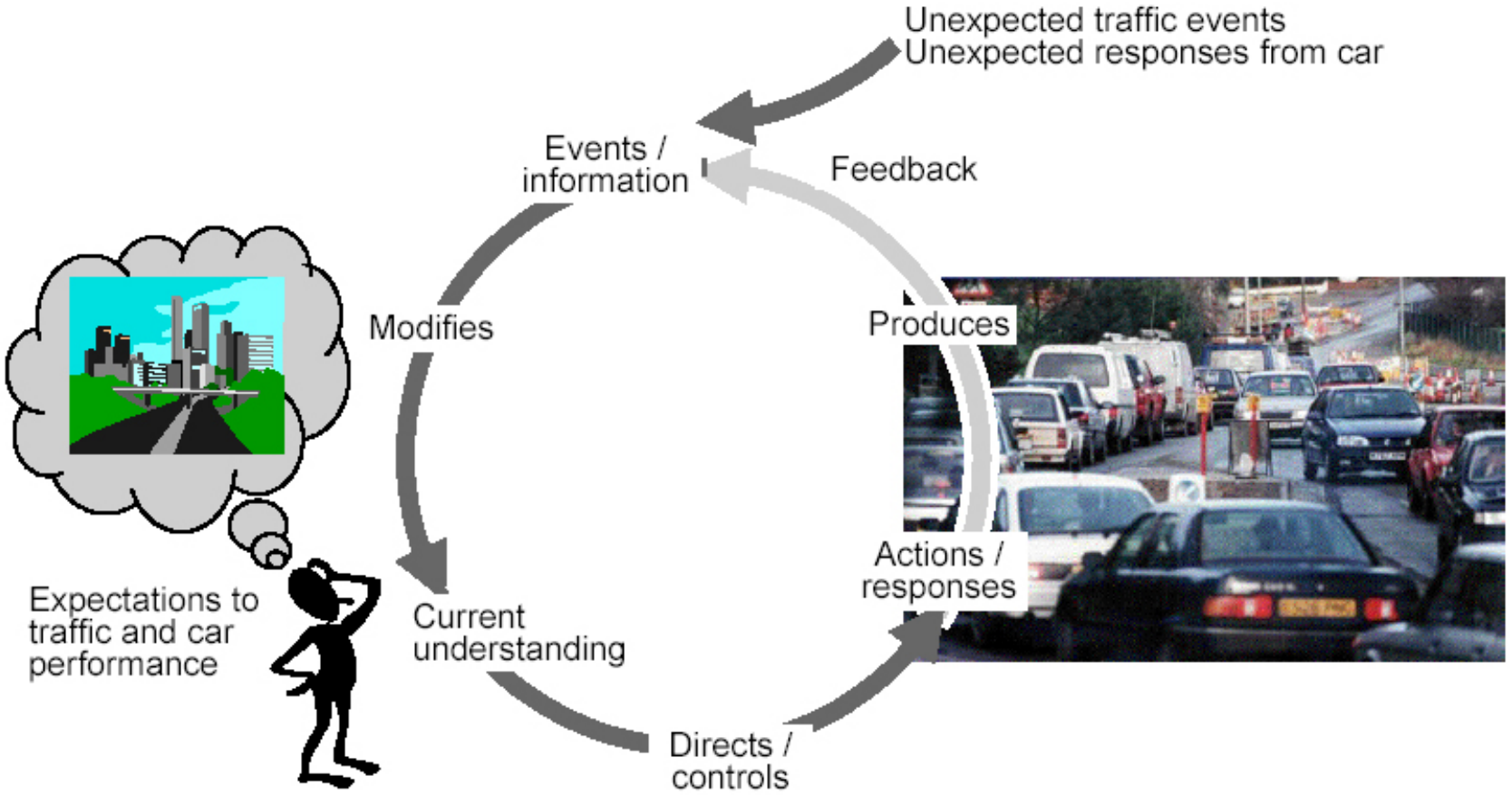
- **COCOM/ECOM (Contextual Control Model / Extended Control Model)**: a qualitative model for Driver-in-Control (DiC) based on the principles of cognitive systems engineering.

→ **Global DVE**
G_DVE

- **IVIS DEMAnD**: In-Vehicle Information System Design Evaluation and Model of Attentional Demand.

→ **Embedded DVE**
E_DVE

AIDE Global DVE model (G_DVE)



AIDE Embedded DVE (E_DVE)

Driver Model

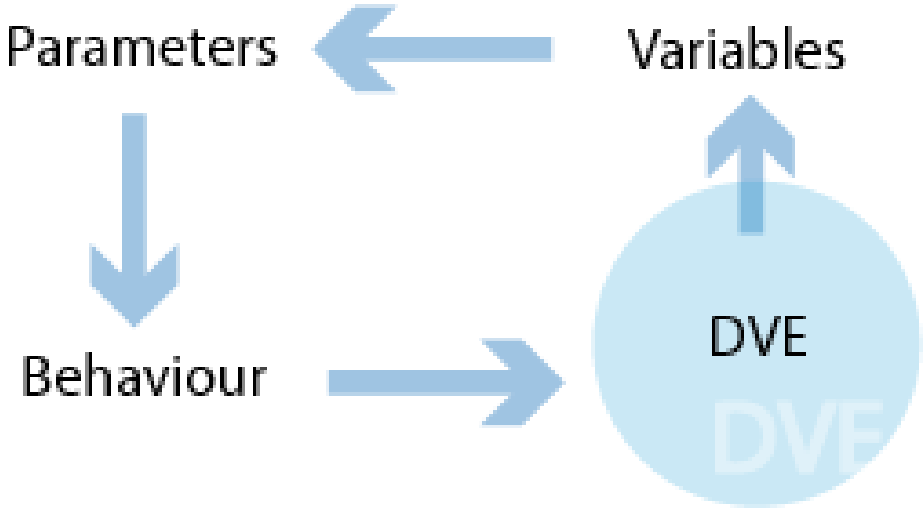
- Tasks
- Parameters and fuzzy correlations
- Simple Model of Joint Cognitive System

Environment

- Road characteristics
- Presence of other vehicles
- Other vehicle, pedestrians, etc.

Vehicle

- Simple model
- ADAS and IVIS simple description

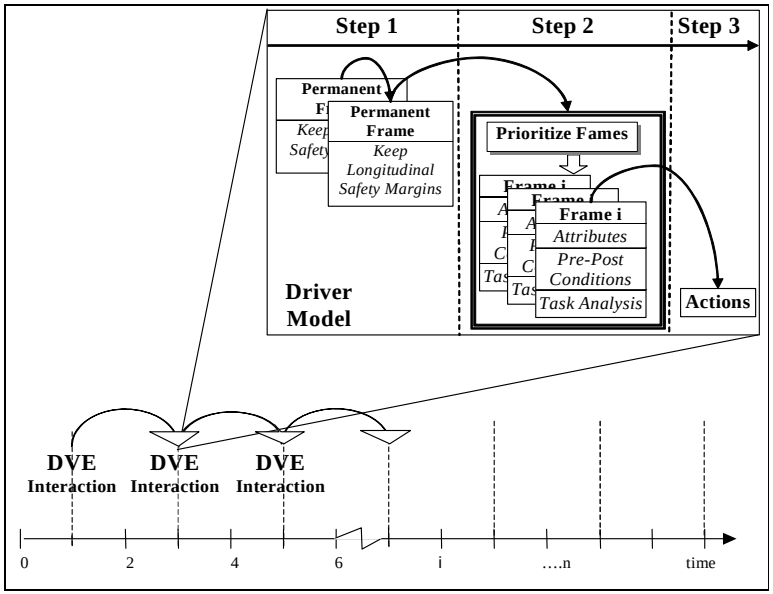


Driver model 1/3

Based on the IPS (*Information Processing System*) approach.

Each instant, drivers follow these tasks (drivers' decision making):

- Attain higher speed, attain lower speed, stop vehicle, turn left, turn right, change lane, overtake, maintain speed
- Permanent tasks: keep lateral safety margins, keep longitudinal safety margins
- Normative and descriptive driver behaviour.



Driver model 2/3

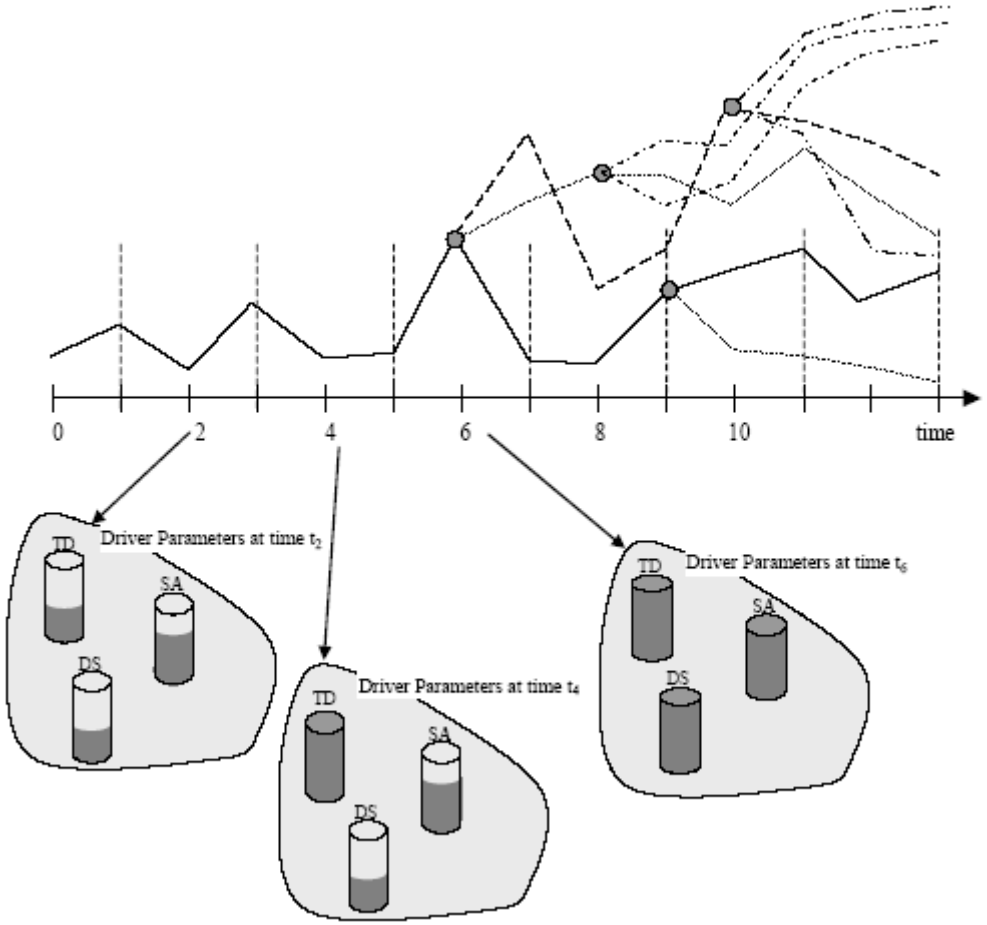
Main parameters describing the Driver model:

- **Experience:** accumulation of knowledge or skills that result from direct participation in the driving activity
- **Attitude:** a complex mental state involving beliefs and feelings and values and dispositions to act in certain ways.
- **Task Demand (TD):** parameter describing drivers' cognitive effort spent during the driving task.
- **Driver State (DS):** driver physical and mental ability to drive.
- **Situation Awareness/Alertness (SA):** perception of the elements in the environment within a volume of time and space the comprehension of their meaning and the projection of their status in the near future.

Driver Model 3 / 3

- Basic Indicators of Driver Operational Navigation (BIDON Model): mechanism that used to describe driver's error and behaviour in relation to the basic parameters.

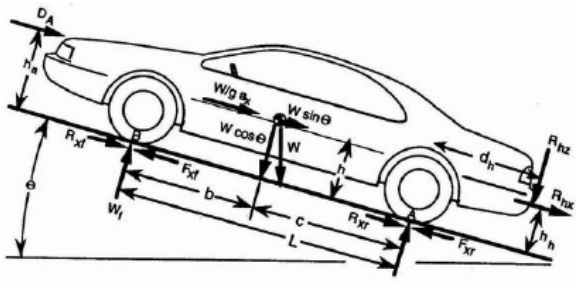
- Drivers' Error Making : the error generation process is essentially associated to a single parameter called Drive Error Propensity (DEP)



Vehicle model

Main signals describing the dynamic and interaction of the vehicle model.

- **Primary task signals**: Speed, Steering angle, Yaw-rate, Number of Brakes, Accelerator pedal position (or throttle information), etc.
- **Signals from external sensors and secondary tasks**: Lateral position and number of Line Crossing, Headway, Time-To-Collision, GSM Module, Vocal module, Navigation system, etc.



$$m \cdot a_x = F_x - R_x - D_A - F_{brake} - W \cdot \sin \vartheta$$

Longitudinal vehicle model equation

$$\begin{bmatrix} \cdot \\ v_y \\ \cdot\cdot \\ \psi \end{bmatrix} = \begin{bmatrix} -\frac{C_f + C_r}{m\,V} & -\left(\frac{C_f l_f + C_r l_r}{m\,V} + V\right) \\ -\frac{C_f l_f - C_r l_r}{J_z V} & -\frac{C_f l_f^2 + C_r l_r^2}{J_z V} \end{bmatrix} \cdot \begin{bmatrix} v_y \\ \cdot \\ \psi \end{bmatrix} + \begin{bmatrix} \frac{C_f}{m} \\ \frac{C_f l_f}{J_z} \end{bmatrix} \cdot \frac{\delta_{sw}}{N}$$

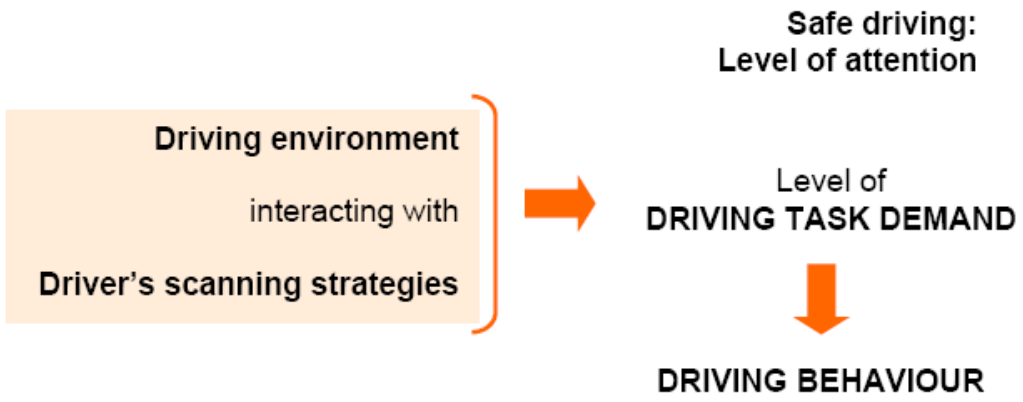
Lateral vehicle model equation

Environment model

Environment model comprises:

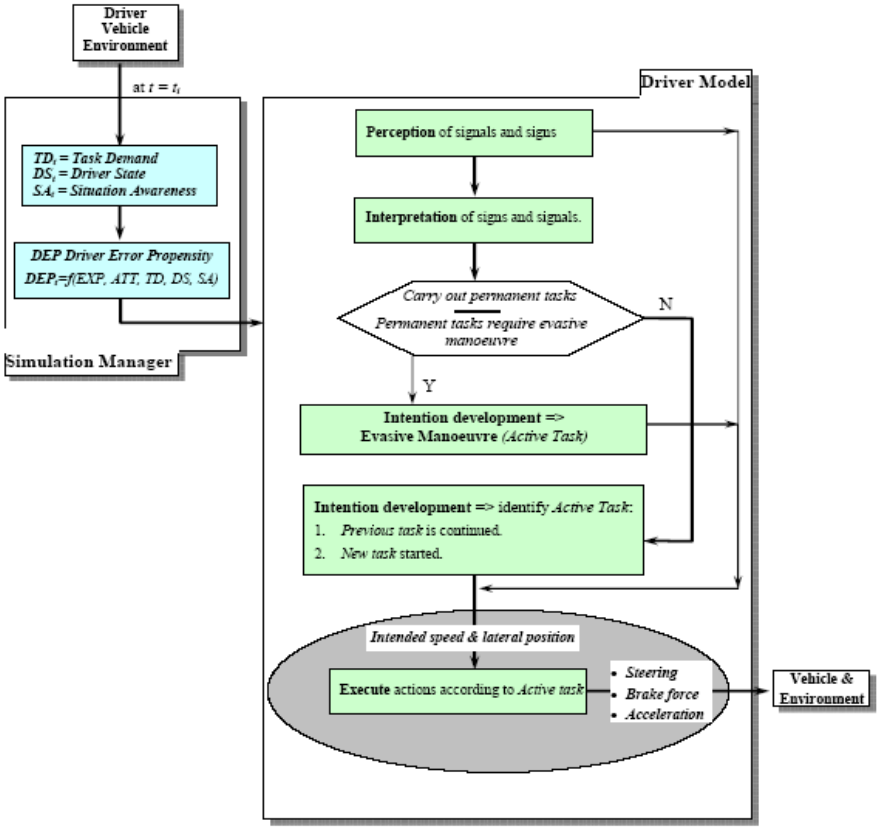
- Road characteristics
- Presence of other vehicles and other obstacles (pedestrians, etc.)
- Weather conditions (visibility)

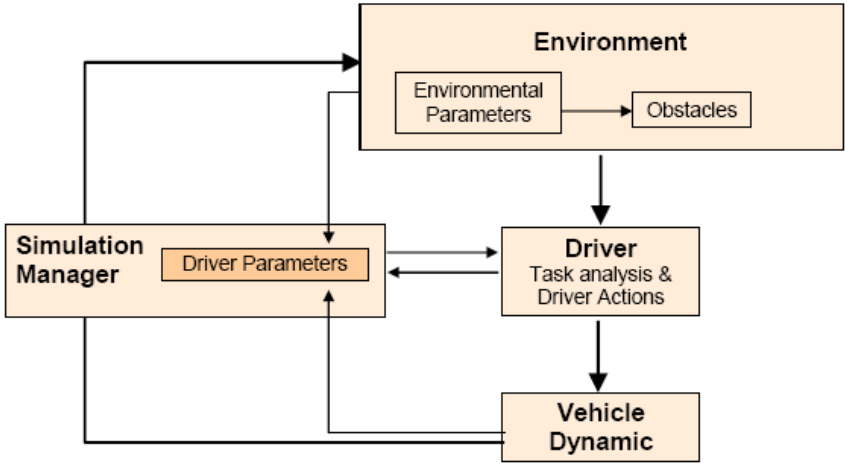
Driving environment is strictly related to driving Task Demand variation.



Computational numeric simulation of the DVE

From the DVE to the SSDrive tool





A vision of the future

Cars and trucks will have a real-time DVE model to assist the driver and to manage the interaction of D - IV - E

where IV = Intelligent Vehicle

= concept of intelligent co-driver

Thus the E_DVE will be embedded in the vehicle

Thank you for your attention!